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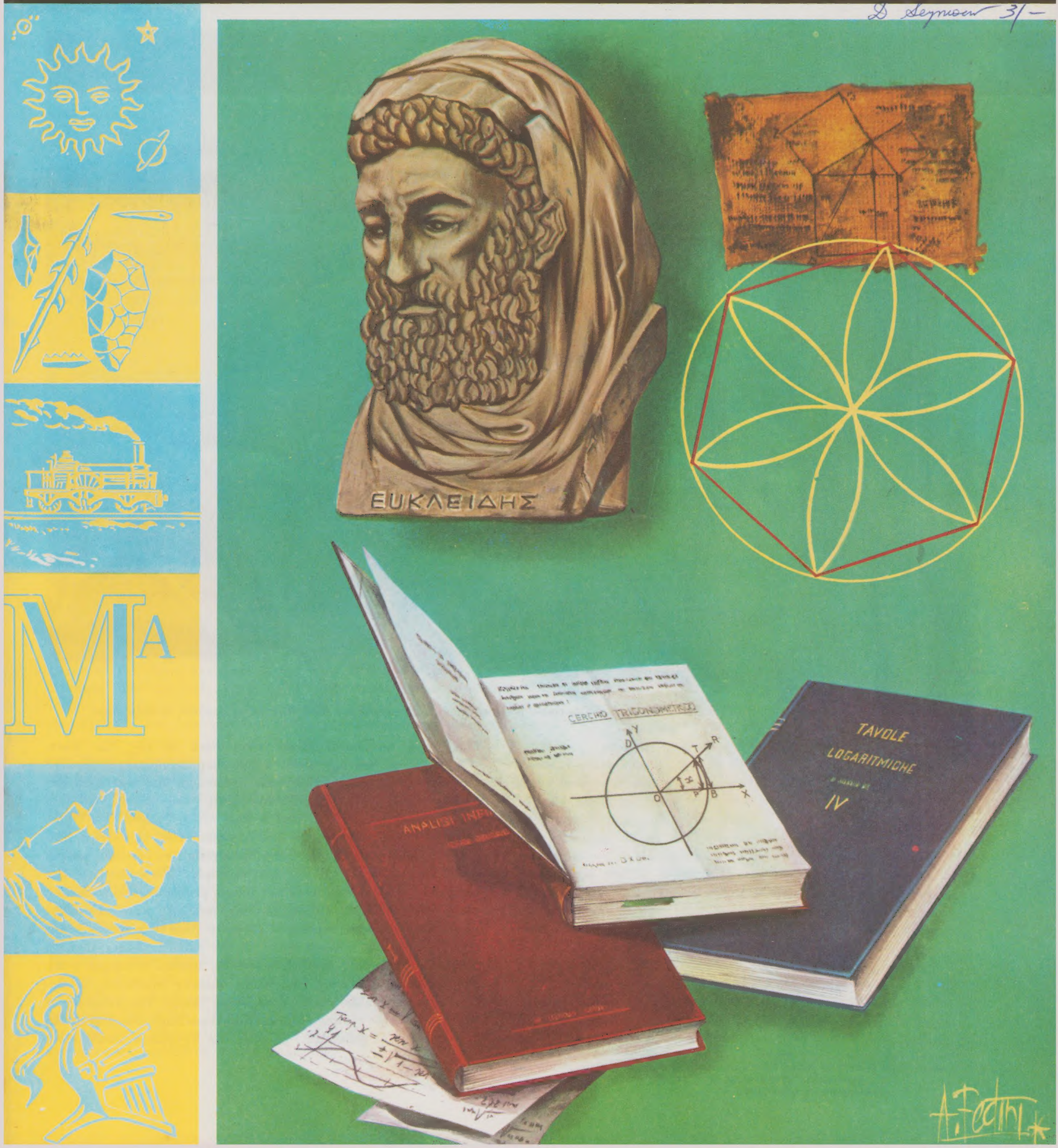

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MATHEMATICS (part one)

ALL of us learn elementary mathematics at school – arithmetic, geometry, algebra, and sometimes trigonometry – and we can all do at least simple calculations. They help us to work out such everyday problems as the change we should receive in shops and the amount that several yards of material will cost if we know the price of one; how many people are coming to a party and how much food and drink they will need; and how long it will take one person to do work normally done in, say, an hour by three people. In fact, it is almost impossible to imagine how we could get through life without counting.

But besides these very simple mathematical calculations, other much more difficult ones affect our lives. For mathematical calculations have made possible the motor car and the aeroplane, television and the telephone. Mathematics forms the basis of the calculations used in physics and chemistry, aeronautics and engineering, and has now become such a vast science that it is impossible for anyone to cover it all.

Prehistoric men needed to count their animals, and would use their fingers, or pebbles, to help them

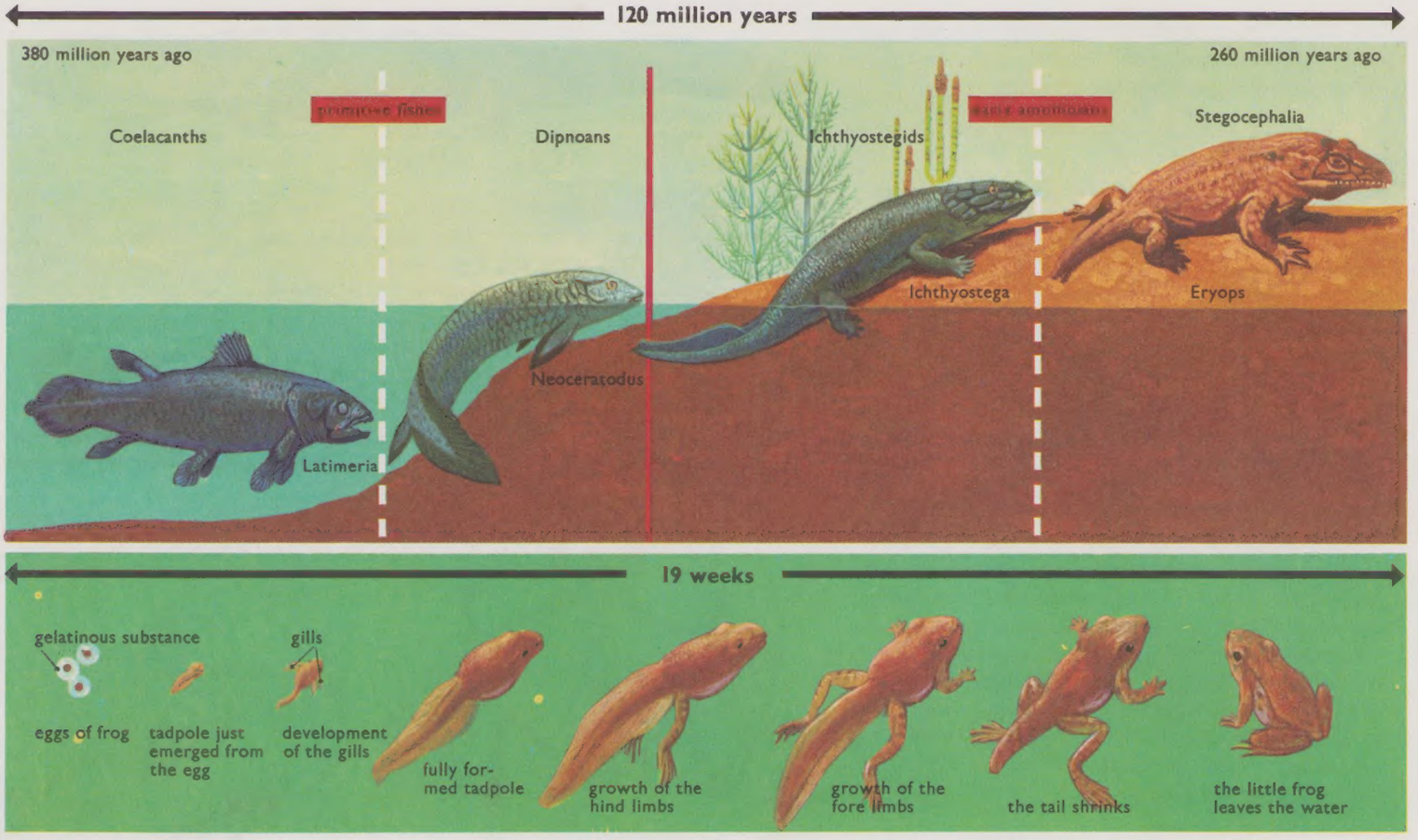
Simple beginnings

The basis of mathematics is numbers. When people first used numbers they knew only one way to work with them, and that was to count. Man in his primitive environment had to provide food for his family, and thus needed an elementary knowledge of counting to work out how many animals he had and which belonged to him. For each sheep or goat he would put aside a pebble (*calculus* in Latin, leading to the English words 'calculus' and 'calculate'). In the most primitive writing (see **Writing**), numbers were usually expressed by strokes.

The numeral one would be represented by a single stroke or line; and the numeral two would be indicated by either || or = . If one writes || quickly, one forms ℕ, which developed into ɴ which was used by the Arabs and Persians; if one writes = quickly, one forms ≂, which developed into the figure 2. The latter horizontal forms were used in the Far East.

A form of writing with wedge-shaped characters, called Cuneiform, was invented by the Sumerians and was used extensively throughout the Middle East from about 3000 B C; the representations 1, 2, and 3 were ▽, ▽▽, and ▽▽▽ respectively. The Babylonians and Assyrians used this script, and it soon spread into Egypt. Using these primitive symbols, people could add, subtract, divide, and multiply. We know that the Egyptians were able to work out simple problems, and that they could use fractions, although their methods were unwieldy. The Egyptians also developed *geometry* (this is a Greek word, literally meaning 'measurement of the earth'). From time to time the river Nile used to burst its banks, sweeping away landmarks and altering its course, thereby increasing or decreasing the taxable value of adjoining lands. The necessity of having a reliable system of measuring those lands resulted in the development of geometry. In fact, the Egyptians would solve

Previous page: A bust of Euclid; an ancient drawing illustrating Pythagoras's theorem; a geometrical construction of a regular polygon; three mathematical textbooks for school use.



Today most amphibians recapitulate or relive in a few weeks the story of their ancestors' emergence from the water and conquest of the land, which took many millions of years. Above: evolution of the Amphibia; below: metamorphosis of the frog

AMPHIBIANS

IN the picture directly above you can see the development of a frog from its original egg. In the picture above this you can see the evolution of primitive members of the Class of animals to which the frog belongs. The pictures have some important similarities. But there is one very important difference. The pictures show 19 weeks of the frog's life . . . but over 100 million years of the history of the amphibians!

Let us look more closely at the top picture. About 380 million years ago there were fishes of the Coelacanth group which were very like the genus *Latimeria*, which still exists. Towards the end of the period some of these fishes acquired the power of breathing air by means of their swimming bladders, as the Australian lung-fish, *Neoceratodus*, does today. Both *Latimeria* and *Neoceratodus* are regarded as 'living fossils' (see page 2163), and we have used them, instead of reconstructions of extinct fishes, in our diagram. About the end of the Devonian Period a creature, known from fossils, had evolved which had developed the limbs of a land animal. This was *Ichthyostega*, which is a link between the fishes and the earliest amphibians. Finally, in the next two periods, the Carboniferous and Permian, fully land-living amphibians came into existence; the one we show, *Eryops*, was about 5 feet long.

Now let us look at the lower picture. First comes the egg, and then the tadpole, which starts life with no limbs, and breathes in the water with gills like a fish. Then it develops limbs and lungs and becomes a land animal, whose life-history is a much shortened version of the evolutionary history of the Amphibia.

CLASSIFICATION

The Amphibia form a Class of vertebrate animals that can be regarded as intermediate between fish and reptiles in the scale of evolution. The derivation of the reptiles from the amphibians is made clear by their fossil history, in the same way as that of the amphibians from the fish which we have described.

The amphibians differ most obviously from fish in having limbs with toes and in breathing air when they are adult. They differ from the reptiles in spending the early part of their lives in water, breathing with gills.

Living amphibians are divided into three Orders:
Order GYMNOPHIONA – Caecilians. Worm-like, burrowing creatures without limbs. Tropical.
Order CAUDATA – Newts and salamanders. Lizard-like amphibians, most numerous in the northern temperate regions. Some, such as the cave-dwelling *Proteus*, never complete their development but breed in the tadpole stage. Animals that do this are said to be *neotenous*.
Order SALIENTIA – Frogs and toads. Tail-less amphibians, world-wide in distribution; about 2,600 species, most numerous in the tropics. Many live in swamps, and a great number of tropical and subtropical frogs are arboreal, living and climbing in trees.

THE BODY. Most amphibians are small, but the Japanese giant salamander grows to over 5 feet, and the African frog *Rana goliath* is 12 inches long.

Relative sizes of some amphibians

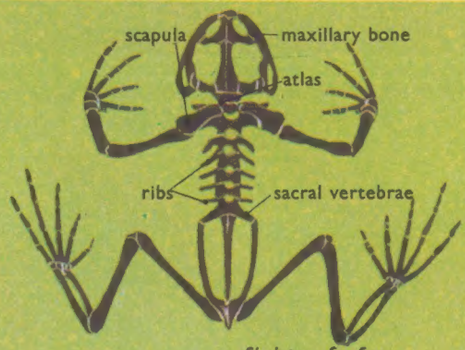
THE SKIN. Amphibians' skin is naked, without any covering of scales. Most amphibians have numerous glands which secrete mucus or slime, keeping their skin moist; toads, however, have a dry skin. Some species have glands in the skin that secrete poison which is given out when they are frightened, and which protects them from being caught and eaten. Toads have a gland on each side of the head; their 'poison' is harmless and merely bitter-tasting, but some South American frogs have a poison in their skin so powerful that the natives use it to poison their arrows.

Amphibians breathe largely by absorbing oxygen through their skins. If a drop of chloroform is put in a bottle, and a frog enclosed in it in the way shown here, it will soon become unconscious, although its head is in the open air, because it absorbs chloroform vapour through its skin.

THE LIMBS. Most amphibians possess four limbs, though some have two and some none. They usually have four digits on their fore limbs and five on their hind ones. The caecilians are worm-like creatures which have no limbs at all, and the *Siren*, a degenerate kind of salamander, has only front limbs. The hind legs of frogs and toads are long and strongly developed for jumping; tree frogs have adhesive pads or suckers on their toes, which enable them to hold on to twigs and leaves when they are climbing.

Front foot of a frog

Hind foot of a salamander



Skeleton of a frog

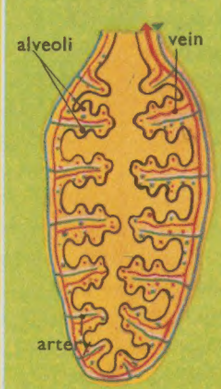
THE SKELETON. Amphibians' skeletons are not strongly developed, and cartilage often takes the place of bone in parts of it. In the skull the cranium is small and narrow and the jaws wide, usually with small, weak teeth; many amphibians, including toads, have no teeth at all. The limbs are of the typical vertebrate pattern; in the frog the two bones of the fore-arm are fused together, and so are those of the shin, while two of the ankle-bones are greatly elongated (see diagram above, right). The vertebrae vary greatly in number, from about 10 in frogs to as many as 300 in some of the caecilians.

The green or edible frog is a common European species

Frogs catch insects by flicking out their sticky tongues

FEEDING. All amphibians are predatory, feeding on worms, insects, and other small creatures. The newts and salamanders seize their prey in their jaws and gulp it down. Frogs and toads have a highly specialised method of feeding. Their tongues are long and often forked at the tip, and lie in the mouth with the tip pointing down the throat. When an insect is sighted the tongue is flicked forward out of the mouth, then quickly withdrawn with the insect sticking to its tip. Larger prey, such as worms, are seized in the jaws.

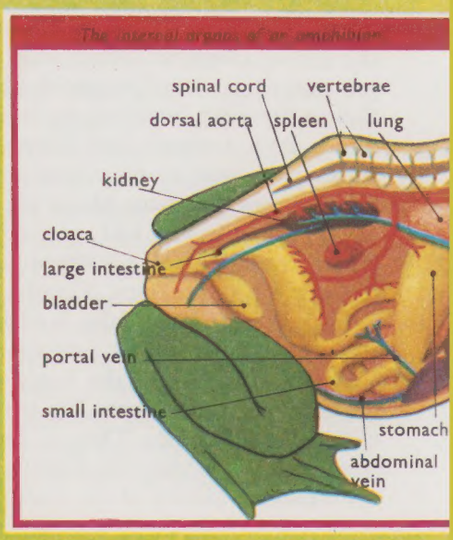
RESPIRATION. As we have said, amphibians live in the water during the early part of their lives, breathing by means of gills. As a tadpole grows, its gills get smaller and its lungs develop. These are very simple and inefficient compared with our own. Amphibians have no 'chest' enclosed by ribs, and no diaphragm, and they do not breathe as we do by expanding their lungs and drawing air into them. They force air into their lungs by raising the floor of the mouth, with mouth and nostrils closed; lowering the floor sucks the air out.



Section of an amphibian's lung

Much of the 'breathing' of amphibians is carried out by their skin, which simply absorbs oxygen from the air, and allows carbon dioxide to diffuse away.

The American lungless salamanders (*Plethodontidae*) breathe only through their skin and through the lining of their mouths.



CIRCULATION OF THE BLOOD. On the right is a diagram showing how the blood circulates in the heart and around the body of an amphibian. For the sake of simplicity the circulation to and from the head (carotid artery and jugular vein) has been omitted. Blood that is fully oxygenated (arterial blood) is coloured bright red; that which has lost its oxygen (venous blood) is coloured blue; and mixed blood is purplish. The heart (see diagram below) consists of three chambers: two auricles and one ventricle; this differs from the human heart in which the ventricle is divided into two. The diagrams are drawn from below, so that left is on the right and right on the left.

Blood comes into the heart through the pulmonary vein and the vena cava; the former carries arterial blood from the lungs into the left auricle, and the vena cava brings venous blood from the body into the right auricle. Both these different types of blood pass into the ventricle, where they are to some extent mixed. The walls of the ventricle act as a muscular pump; when they contract, valves prevent the blood from going back into the auricles. That on the left side (mainly arterial) is forced into the artery called the systemic arch, while the venous blood on the right side goes into the pulmonary artery, which takes it to the lungs to be oxygenated. The systemic arch carries the arterial blood to various parts of the body, where it gives up its oxygen and eventually flows into the vena cava, and so back to the heart.

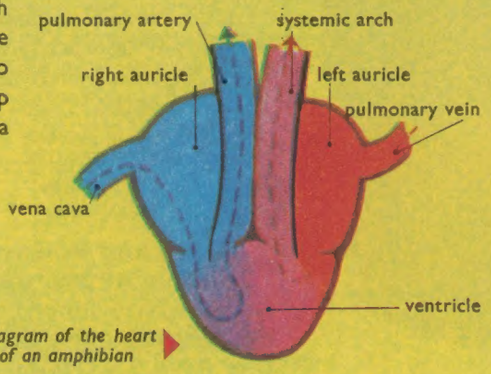


Diagram of the heart of an amphibian

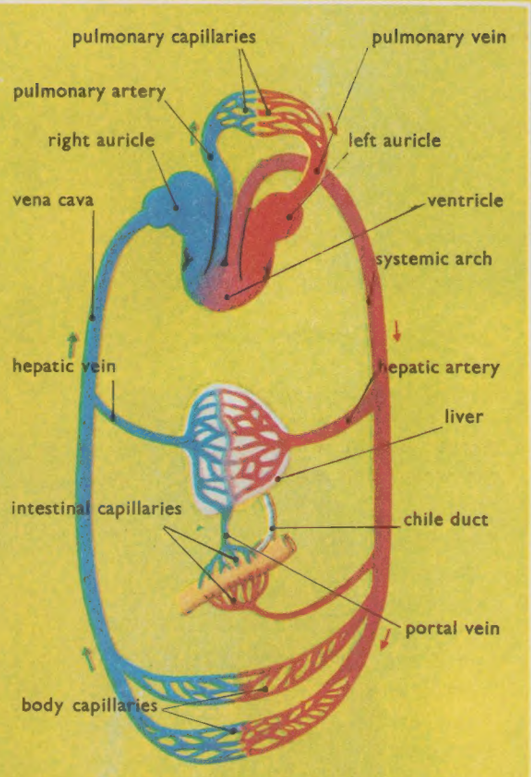


Diagram of the circulation of an amphibian

BODY TEMPERATURE. The body temperature of amphibians varies with their environment. In cold weather their blood chills, and they become inactive; in cold climates they have to hibernate in winter. In this they resemble reptiles, but differ from birds and mammals, which keep their blood at a constant temperature.

THE BRAIN. The brain of amphibians shows very little advance on that of fish. The optic lobes are usually large, and so are the cerebral hemispheres of the fore-brain. The cerebellum, associated with balancing and co-ordinated movement, is small. Amphibians have some power of learning and can be tamed and taught to come and accept food from their owner, but they cannot be said to be intelligent.

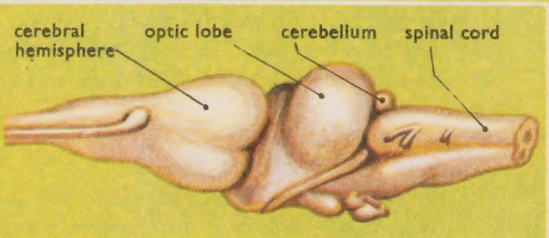
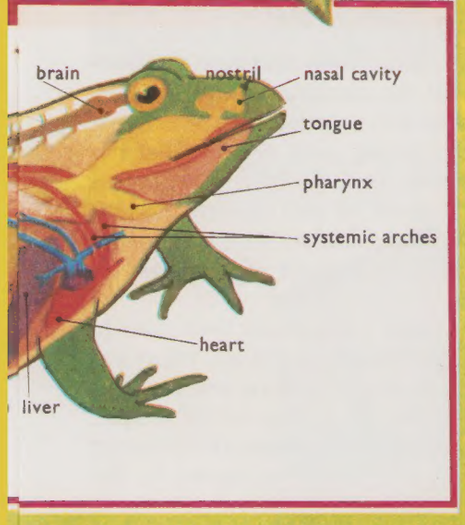
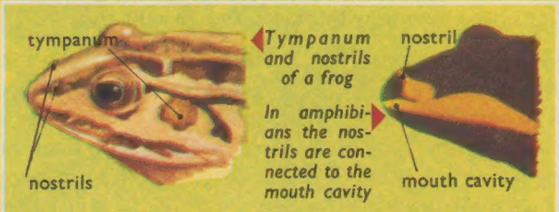


Diagram of the brain of a frog





Tympanum and nostrils of a frog

In amphibians the nostrils are connected to the mouth cavity

SENSES. The higher amphibians – frogs and toads – have acute senses. They hunt their prey by sight, and keep watch against enemies. They hear well and have loud voices to communicate with each other; the ear or tympanum of a frog is clearly visible on each side of its head. The sense of smell of amphibians, especially the blind and burrowing forms, is acute.

REPRODUCTION. Most amphibians reproduce by laying eggs, and these are usually laid in the water so that the aquatic young find themselves in their proper environment. Many tree frogs lay their eggs on vegetation overhanging water, so that the tadpoles fall in when they hatch. The South American tree frog *Eleutherodactylus* lays large eggs in cavities in trees, and development takes place inside the egg. Some salamanders bear their young alive.

Egg of Eleutherodactylus *containing fully developed frog*

THE WELFARE STATE

Lord Beveridge (1879–1963), who produced the report on which the Welfare State of today is based

IF you live in the United Kingdom, you live in a Welfare State. If you are young, you may take this for granted. You accept that when the doctor calls you do not have to pay for his services, and, indeed, if you have to have complicated medical treatment you do not have to meet the cost. You can also get an excellent education free, and if, in the future, you are ever out of work the State will pay you money and try to find you another job. In fact, the Welfare State provides people today with many benefits quite unknown to their great-grandparents.

What is the Welfare State?

The Welfare State is a national community which is organised in such a way that no member of that community need live below a certain standard. In order to achieve this, its members contribute a certain amount of money into a central fund.

How it began

For most people the 19th century was a very unpleasant time to be alive. Even if you were poor (and the majority were poor) you had to pay for many services which are now given free; if you were ill, for example, the doctor expected to be paid a fee. Few people worried about the working conditions in the mills and factories. Young people would not be preparing for their 'eleven plus' – many of them were likely to be underground in coal mines. They hardly ever saw the light of day, such long hours did they work. There were a few people, such as Lord Shaftesbury (see page 2160), who were successful in doing something about the wretched conditions in factories, mills, and mines. But one trouble was the widely held doctrine that everyone would be better off if the State did not interfere with individuals (*laissez faire*). The rich were certainly well off, but few bothered about the poor; moreover, many attempts to improve the wretched conditions by legislation were met with cries that the government should not interfere with the sacred principle of *laissez faire*. Despite, and in the teeth of, this opposition, however, many worthwhile measures were passed in the 19th century: Education Acts, Factory Acts, Health Acts, and so on. This legislation was the beginning of the Welfare State because it established the principle that the State had a duty to ensure that the people of the country had a certain basic standard of living.

But there were many problems to overcome before social justice could be given to all. Under the Poor Law Acts (see page 2202) many services had been set up for the poor. There were Poor Law hospitals, Poor Law infirmaries, and Poor Law workhouses. But these were not the type of services that people in need would willingly turn to for help. You have undoubtedly heard of the workhouses to which people with no money and no employment, such as widows and orphans, were sent. They were organised by 'guardians' and were not very pleasant places. This system was particularly unjust because it implied that poverty was a crime or, at the least, degrading in the eyes of society.

Booth and Rowntree

But this attitude was questioned during the closing years of the 19th century. The work of private investigators like Charles Booth and Seebohm Rowntree, working in London and York, showed that poverty had many causes: low wages, large families, irregularity of employment, and unemployment. When these two men published their findings in *Life and Labour of the People in London* (Booth, 1903), and *Poverty: a Study of Town Life* (Rowntree, 1901), it became obvious that the existing social services were not doing their job. Social reformers, religious leaders, and politicians of many different schools of thought began a national attack on the problem of poverty.

Sidney and Beatrice Webb

The government of the day reacted by setting up a Royal Commission in 1905, which was to inquire into the working of the Poor Law and other efforts to deal with the stress arising from unemployment. In 1909 this body prepared two reports. The Majority Report did not propose any big changes in the Poor Law, although it did recognise that poverty should be treated on a nation-wide scale and not just left to local initiative. It called for greater assistance from the central government.

The Minority Report was largely the work of Sidney and Beatrice Webb, although only Mrs Webb was on the Commission. This Report stated that the conditions of life of many people were such that they could not, unaided, escape extreme poverty. The remedy lay not in giving poor people relief but in preventing them from becoming poor. Children, the Report maintained, should be properly cared for and educated; adults should be protected against sickness, disablement, and unemployment; and the elderly should be assured of a modest income.

The Webbs pointed out that much had already been done in the spheres of housing, health, and factory conditions. What was now needed was to break with the old Poor Law and set up a nation-wide organisation to care for the welfare of the people. This reform was not carried out until the 1940s, but the Minority Report was, nevertheless, one of the great milestones in the history of the Welfare State.

A 'home help', provided by the State, visits a sick mother

This patient is receiving free hospital treatment

Liberal reforms

Largely as a result of the findings of the 1905 Commission, the Liberal government laid down, between 1906 and 1914, the foundation of the services that were later to expand into the Welfare State. During these years the government introduced non-contributory old age pensions (a regular income for old people), unemployment insurance and health insurance (regular contributions which would ensure either an income when out of work or payment for medical treatment). What was important about these services was that they were not provided as charity. They were given to the people who needed them as their right, for these people had made regular contributions (together with their employers and the State). When a man was unemployed he could feel that, in receiving payments from the State, he was merely receiving his due. Although poverty and suffering were by no means eliminated, the 1906–1914 Liberal government made a big break with the degrading principles of the Poor Law.

Dental treatment is provided free for those under 21 and at reduced rates for adults

Between the wars

Between 1914 and 1945 Britain lived through two wars and a nation-wide depression. These years saw the development of a trained army of civil servants who were used to organising the ordinary man's life in detail. The war years taught all sections of the community to look to the State for instructions and solutions to their problems. In fact, the State was expected to run certain areas of people's lives, and was becoming organised to do so.

The administration of the various welfare services became more efficient, and the special hospitals and infirmaries, previously run by the Poor Law, were handed over to the local authorities. Indeed, most of the services provided by the Poor Law came to be administered by local authorities. The name 'Poor Law' was changed to 'Public Assistance'; this was now provided by the local authorities and gave help to the infirm, widows, orphans, mentally ill, tramps, vagrants, and so on.

Council houses are provided for many people at reasonable rents

Unemployment. The years between the wars still provided many great problems, perhaps the greatest being unemployment. It reached an appalling level during the Great Depression (see page 2644). New measures were brought in and new services provided to care for the unemployed and their families. Special payments were made to those for whom unemployment insurance was inadequate. This was the 'dole'.

Housing. Housing was another serious problem, which the government tackled by building new cheap houses and clearing slums. From 1909 successive Acts of Parliament recognised the need for planned use of land. The 1932 Town and Country Planning Act was a major step forward, and remained the basis of planning law for the next 15 years.

Education. There had been several Education Acts in the 19th century. School-leaving ages had been raised, and by the end of the century primary education was available to all. But in 1914 only 56 children in every 1,000 had any secondary education. By 1929 this proportion had doubled.

All this shows that during the 1920s there was progress towards a Welfare State. The State attempted to alleviate the worst poverty; a better education could be obtained free; there was a small measure of security in old age (the old age pensions had again been raised); ill health was not necessarily a disaster; and some of the worst slums had been cleared (though there were still plenty more). However, all the measures enumerated were only to combat specific problems, and, as yet, there had been no 'master plan' to give everyone a certain standard of living.

Beveridge

In 1941 the government set up a committee to look into the existing scheme of social insurance. The chairman of this committee was Sir William Beveridge.

The committee soon decided that a major restatement of social policy was called for, and the Beveridge Report, produced in 1942, was to form the basic pattern of our Welfare State. It put forward a comprehensive plan to combat the five great 'giants' – Want, Disease, Squalor, Ignorance and Idleness. Each citizen was to be provided with complete social security as well as *comprehensive* health and education services, a good house, and enough money to live a reasonable life.

Today nearly all Beveridge's suggestions have been carried out. They were embodied in the Education Act of 1944, the Family Allowances Act of 1945, the National Insurance and Industrial Injuries Acts of 1946, the National Health Service Act of 1946, the Children Act of 1948, and the National Assistance Act of 1948. These Acts form the basis of our Welfare State.

The Welfare State today

Let us now take a look at the way the services of the Welfare State affect us and what we gain from them. First, where does the money for them come from? There are four sources; we all contribute *indirectly* through the rates, which we pay to our local authorities, and through taxes which we pay to the central government either on our incomes, or on purchases like cars and refrigerators. We also contribute *directly* through specific contributions. Since the services are paid for both locally and centrally, local authorities and the central government share their administration.

Social security

The social security scheme in Britain provides benefits which mean that no one's standard of living need fall below a certain reasonable level.

National Insurance. Every person living in Great Britain who has finished his education and is under pensionable age becomes insured under the National Insurance Acts which date from 1946. An insured person is entitled to unemployment and sickness benefit, or retirement pension, and a grant to his family when he dies. All insured women are also entitled to maternity allowances and widows' allowances. The contributions are shared between the insured person and his employer, by means of insurance stamps which can be bought at the Post Office and which also help pay for the National Health Service. The contributions are usually graded according to how much a man earns.

Industrial Injuries Insurance. This protects people who are injured or fall ill as a result of the type of work which they do. Both employer and employee contribute to the scheme.

National Assistance. This is designed to supplement certain existing services. People in particular financial need can apply for help to the National Assistance Board, and the scheme also provides old age pensions and family allowances for those who have paid no contributions.

Elderly people who are not able to look after themselves can be cared for in their homes by the State

Family allowances are regular sums of money provided by the State for each child in the family (except the eldest) under the age of 16, or up to 18 if the child is still being educated.

State education

In England and Wales the State is responsible for the education of all children, including the mentally and physically handicapped. This means that until he is 15, every child can have a free education. He is also provided with very cheap meals at school. The system is organised under the Education Act of 1944, with later amendments. The three stages of education are: *primary*, which includes nursery schools up to the age of 5, infants' schools (5–7), and junior schools (7–11); *secondary*, which includes grammar schools (an academic education), secondary technical schools (more practical), and secondary modern schools (general and practical). These secondary schools are sometimes combined in a comprehensive school. The third stage is known as *further education*, and includes training and technical colleges, county colleges, colleges of art and commerce, evening institutes, adult education, and universities. Those who are awarded a place at a university or training college can apply for a grant to cover all or part of the cost; education at the other institutions costs very little.

Inexpensive meals are provided in State schools

University grants make higher education available to people who otherwise could not afford it

Housing

The provision of houses at reasonable rents is part of the Welfare State service. It is organised completely locally; each local authority makes its own system of allotting the houses in its district, but they are usually awarded on a 'points' system. This takes into account such considerations as how long the applicant has lived in the district, the size of the family, its income, and its state of health. In all districts slum inhabitants have priority. The cost of these houses varies considerably throughout the country, but it is quite usual for a three-bedroomed house to be rented for 30*s*. a week.

National Health Service

The National Health Service Act of 1946 made the Ministry of Health responsible for providing health services of all kinds and of the highest standard. These services are available to everyone resident in the country, and include medical, dental, and ophthalmic treatment, hospitals, specialists, local authority services such as midwifery and ambulances, and prescriptions (drugs, spectacles, and so on).

People, of course, need not make use of the State system; but it is there for those who want or need it.

The flower of the familiar daisy does not form a pappus, and so its seeds are not dispersed by the wind like those of the dandelion

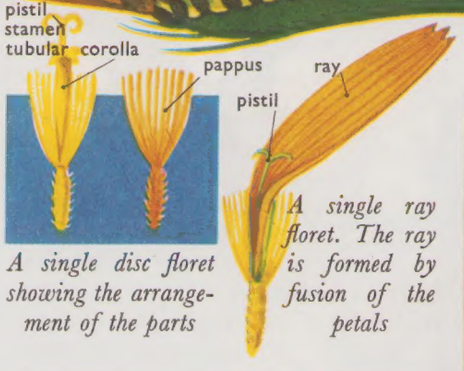
COMPOSITE FLOWERS

EVERYONE knows the yellow sunflower, yet how many of its admirers know that it is not really the single flower that it appears to be, but a great number of tiny *florets* all packed closely together on a single stalk? The sunflower is, in fact, a *composite flower* and thus a member of the botanical Family known as the Compositae.

Species of Compositae are found in almost every part of the world. In temperate climates the native species are generally herbaceous; in warmer lands bushy and tree-like species are found.

The complex flowers of the many species of Compositae are arranged in a characteristic manner. At the top of each flower is a widened part known as the *receptacle*. From the upper surface of the receptacle spring large numbers of tiny florets, closely packed to form the flower head or *capitulum*. From the lower part of the receptacle the *involucrum* of green *bracts* originates. It protects the flower when it is in bud, rather like the calyx of sepals in a simple flower. In some of the composite flowers, like the dandelion, the florets are all the same, but in the sunflower and the daisy the central or *disc florets* are small, and their five petals are united into a slender tubular *corolla*. The outer *ray florets* are larger; their petals have strap-like extensions which, pointing outwards, form a bright ring around the capitula. Each floret has five stamens, the anthers of which are united around the *style*. Each ovary contains a single seed. In some Compositae the flower is succeeded by the formation of a *pappus*, a device for distributing the seed with the aid of the wind. In the dandelion this is the familiar 'clock', and in the thistle the fuzzy head.

This sectional view shows many of the characteristic features of the composite flower. The large number of tiny florets of which the flower is formed can be seen springing from the receptacle. In the centre are the disc florets. The ray florets are arranged around the periphery of the flower with their strap-like petals extending outwards

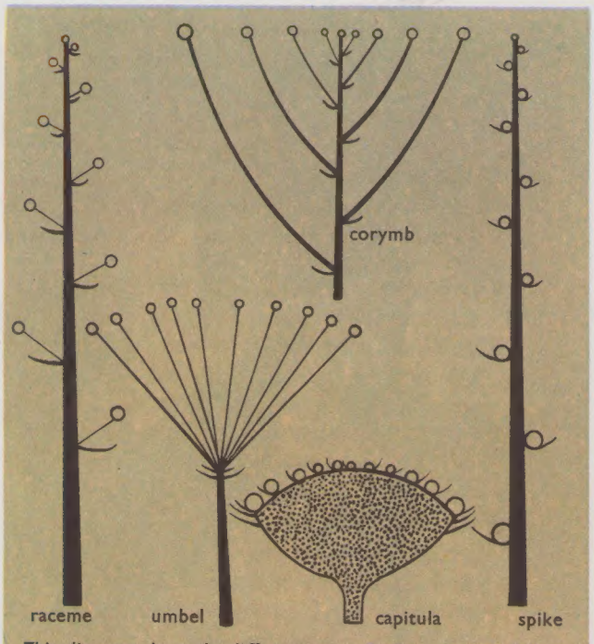


A single disc floret showing the arrangement of the parts

A single ray floret. The ray is formed by fusion of the petals

THE LARGEST FLOWERING FAMILY

The Compositae is by far the largest Family of the Phanerogams, or flowering plants. In all there are approximately 13,000 species. A few species, such as the lettuce, the artichokes, and the chicory plant, have commercial value as foodstuffs. Others have medicinal uses. But most species are grown simply because they are decorative.



This diagram shows the different types of inflorescence. All the Compositae are arranged with a capitulum

EDIBLE SPECIES

Lettuce (*Lactuca sativa*). Few people see lettuce looking like this, for only seed merchants allow their crops to grow to maturity. Leaves from a mature plant usually taste bitter.

Chicory (*Cichorium intybus*). In Britain a leafy variety is grown for salad. In much of Europe roots of the Witloof variety are used as a vegetable.

Sunflower (*Helianthus annuus*). The great height of this plant and the huge size of its flower make it easily recognisable. In Britain it is almost always grown for ornamental purposes, and few people know that the seeds can be used in cooking. In many countries sunflowers are grown as a crop. The large seeds harvested from the flowers are crushed in a mill to yield a product much like olive oil. The residue can be used to make cattle cake.

Jerusalem artichoke (*Helianthus tuberosus*). This plant is rather like the sunflower, though its flowers are much smaller. The tuberous roots are prepared and cooked like potatoes.

Globe artichoke (*Cynara scolymus*). This plant is grown both for its attractive, thistle-like flowers and for its edible buds. The buds are cooked in salty water, and are often served with a little melted butter.

ORNAMENTAL

Chrysanthemum (*Chrysanthemum indicum* and *morifolium*). These two are probably the parents of the many beautiful varieties popular today.

Cornflower (*Centaurea cyanus*). This annual species of cornflower is cultivated in blue, pink, and white varieties.

MEDICINAL SPECIES

Leopard's bane (*Arnica montana*). This flower is used as a herbal remedy for sprains. The injured joint is bathed in a tincture prepared from the flower and root and hot water. The tincture is sometimes taken internally, but as some people react violently to it this treatment cannot be recommended.

Zinnia (*Zinnia elegans*). Several species of zinnia have been developed for the flower garden. Their bright colours, and the ease with which they are cultivated, make them very popular.

French marigold (*Tagetes patula*). This and several other species of marigold are familiar garden flowers.

Everlasting flowers (*Helichrysum*). There are many species of *Helichrysum*, with flowers in a great variety of colours. It used to be a common custom to cut the flowers and dry them in a cool room for winter decoration.

Dahlia. The many species of dahlia originated in Mexico. They have tuberous roots and very bright, showy flowers. They are named after the Swedish botanist, Andreas Dahl.

Daisy (*Bellis perennis*). Small varieties found in lawns are regarded as weeds; larger cultivated varieties make gay edging plants.

AROMATIC SPECIES

Wormwood (*Artemisia absinthium*). The odoriferous leaves of this plant are used to make a distillate, which is employed as a flavouring agent in the liqueur known as absinthe.

Mugwort (*Artemisia vulgaris*). The bitter taste of mugwort has made it a popular flavouring in many drinks. It was at one time used in beer.

Camomile (*Matricaria chamomilla*). This little plant, which is used for the preparation of camomile tea (a nerve tonic and sedative) in many parts of the world, is slightly different from the camomile (*Anthemus nobilis*) found in Britain. One distinguishing feature of *Matricaria chamomilla* is the elongated oval receptacle.

Coltsfoot (*Tussilago farfara*). This plant grows wild in many parts of Britain. Its flowers and leaves are used to make herbal remedies for the treatment of chest complaints, particularly asthma. Its leaves are sometimes used for herbal cigars.

INSECTICIDAL SPECIES

Within the family Compositae is the genus *Pyrethrum*. Examples of this plant are found in many flower gardens, and three species of it have considerable commercial value as they are the source of the insecticide, *pyrethrum*. This substance is obtained from the dried and powdered flower heads, and it is incorporated in fly killers to provide a quick knock-down effect.

JOHN WYCLIFFE

Wycliffe's trial before the Bishop of London at old St Paul's is cut short by Gaunt's men

THE driving force for the Reformation (the Protestant movement in which large areas of Europe broke with the doctrines of the Roman Catholic Church) came from outside England. Indeed it was due to the ideas of men like Luther (see page 1248), Calvin (see page 2110), and Zwingli that England became a Protestant country. But long before these men were born there was a 'protestant tradition' which originated in England. Its founder was John Wycliffe, whose astonishingly advanced doctrines have earned him the title, 'the Morning Star of the Reformation'.

Little is known about Wycliffe's early life. He was born in 1327 in Yorkshire; he went to Balliol College, Oxford, to study for the priesthood; and shortly after 1356 became Master of Balliol. In 1361 he accepted the living of Fillingham in Leicestershire, and four years later was appointed warden of Canterbury by the Archbishop of Canterbury. But a quarrel broke out between the monks and the 'seculars' (non-monastic clergy, of which Wycliffe was one). The case was referred to the Pope, and, in 1371, judgment was given against the secular priests.

Critic of the Church

Some people think the 1371 judgment was responsible for Wycliffe's hostility to the Church authorities. Yet long before this he had gained a great reputation at Oxford as an outstanding and controversial theologian. He was unrivalled in theological debates, and in 1366 had been invited to address Parliament on the question of Papal taxation. This was a difficult problem, for the Papacy was in residence at Avignon, under the influence of the kings of France – England's deadly enemies at this time. Wycliffe supported Edward III's policy of refusing to allow money to go to Avignon. Some time after his speech in Parliament he wrote *Determinatio quaedam de dominio* (A definition of lordship) in which he supported the rights of the State to legislate in such matters. Wycliffe's arguments pleased the government, which was becoming increasingly hostile to the Papacy. He came to the notice of John of Gaunt, a leading anti-papalist, who wanted to obtain money for his projected wars with France. Gaunt's patronage gained Wycliffe the rectorship of Lutterworth in Leicestershire (1374), a position he held until his death. The same year he travelled to Bruges as a delegate over the question of Papal 'provisions' – the Pope's habit of giving positions in the English Church to whom he wanted. Wycliffe attacked the Pope on this subject, but the negotiations came to nothing. On his return Wycliffe settled down to serious propaganda, and his fame as a popular and respected preacher spread widely.

Condition of the Church

It was not difficult to criticise the 14th-century Church. Many monasteries had virtually ceased the great charitable works of their hey-day, and the Black Death had left them with fewer monks than they should have had. The ordinary clergy were often poor and illiterate, although the higher clergy lived on a scale of splendour which aroused almost universal hostility. Many convents had become retreats for the unmarried daughters of wealthy families. All this Wycliffe attacked, and, in an age of anti-clericalism (hostility to churchmen), his popularity soared. Yet Wycliffe, at this period, still supported the friars – dynamic and popular Franciscans and Dominicans, to whose sermons and confessionals people flocked, and who wandered through the country, keeping to the ideals of apostolic poverty.

Wycliffe's great theme was opposition to the Papacy and the Papal system. At first he attacked only the Pope's political claims. He is thought to have inspired the anti-Papal legislation passed by the Good Parliament in 1376 (see page 2638), and that autumn he produced one of his most important works, the treatise, *De civili dominio* (On civil lordship). In this he argued that rights to everything, including property, came directly from God. Bad men, the 'unrighteous', forfeit their right to all 'dominion' – that is, to have authority and material possessions. Unrighteous clergy should be deprived of their property, but, he went on, as the Church should be concerned purely with spiritual matters, all property in the hands of clergy was basically sinful. Wycliffe maintained that the

decision as to a person's suitability for holding property depended on the civil power, the government of the State, *not* the Church. In this assertion Wycliffe not only came into the open in his support of the State against the Church, but implied that a seizure of the Church's property by the State was called for.

As a result of these propositions Wycliffe was summoned to St Paul's Cathedral to appear before the Bishop of London and answer charges of erroneous teaching. He appeared on 19th February 1377, with John of Gaunt and other supporters. Before Wycliffe could speak, the meeting was broken up by a riot in which Gaunt's men, supported by a tumultuous mob, attacked the Bishop's men. Wycliffe was hurried from the cathedral. Inevitably, it was not long before the matter was referred to the Pope.

John Wycliffe (1327–1384)

On 22nd May 1377 five Bulls, which condemned 18 of Wycliffe's 'conclusions', were published by Pope Gregory XI. 17 of these came from *De civili dominio*. The Bulls ordered Wycliffe to be imprisoned until the charges were investigated. Despite this, Wycliffe remained as influential as ever. In the autumn of 1377 he was consulted by Parliament as to whether it was lawful for the government to prohibit treasure leaving the country to go to the Pope. Wycliffe, of course, said yes.

After much wrangling, Wycliffe was brought before clerical judges at Lambeth Palace early in 1378. But, as at St Paul's, this 'trial' came to nothing – an urgent message arrived from the Princess of Wales commanding that no judgment should be given. In the autumn of that year John of Gaunt violated sanctuary by having two of his enemies attacked, and one murdered, in Westminster Abbey. Gaunt was, of course, condemned by the Church authorities, but Wycliffe pleaded his case before Parliament. He argued that it was perfectly legal for the civil power to over-ride Church law where civil law had been violated.

In this year a great scandal in the Church encouraged Wycliffe to even more extreme views. 1378 was the year of the Great Schism, when Clement VII was elected Pope by the French party as a rival to Urban VI who had moved the Papacy back to Rome. This split, with two Popes hurling abuse and excommunications at each other, gave Wycliffe cause to be even more outspoken against the Papacy. He was now preaching the virtues of sending 'simple' priests to preach up and down the country, and had begun his great translation of the Bible into English. This was the first ever complete translation, and it brought the Bible to far more Englishmen than previously.

Whether it was due to the Schism or the natural progress of his thought, Wycliffe, after 1378, became much more extreme and definitely heretical. He began to attack one of the very fundamentals of the Church – the spiritual powers of the priesthood. In this attack he included the friars, and from now on Wycliffe became unreservedly anti-clerical. Between 1378 and 1379 he produced a series of learned works in Latin, including *De officio regis* (On the office of kingship) which virtually asserted that the king was head of the Church. He declared that the Pope was anti-Christ and unfit to rule, and attacked transubstantiation and confession. This was just about the most serious thing he could do, for the daily miracle of changing the Communion bread into the Body and Blood of Christ through consecration (transubstantiation) was largely responsible for the hold the priesthood had over the common people. And, of course, the priestly power to forgive sins was almost as important. In 1381 Wycliffe produced *De eucharistia* (On the eucharist), in which he denied that Christ was physically present in the Communion bread.

Such doctrines were, of course, condemned by the Church, and Wycliffe had gone too far, even for the English government. Gaunt requested his protégé to be silent, and a rift developed between Wycliffe and the Court which was widened by the Peasants' Revolt in 1381. Wycliffe was accused of inciting this revolution – an unjust charge, although it is quite possible that the 'communistic' implications of his theories of lordship played some part. He was condemned by the Archbishop of Canterbury, although the University of Oxford continued faithful to the reformer. In these last years Wycliffe produced some of his most important works, including *Trialogus* in which he summed up his theological and philosophical ideas.

On 28th December 1384 he had a fatal stroke. He died on New Year's Eve. He was buried at Lutterworth, but the Council of Constance in 1415 ordered his bones to be dug up and burned.

Wycliffe was not a particularly original thinker. Others, including Chaucer (see page 348), were criticising the Church at this time. His support of the State against the Church, and his notion that the government of the Church rested on all the faithful and not the Pope alone, was in part a restatement of the ideas of Marsilius of Padua (1270–1342).

In England Wycliffe's followers became a persecuted sect, the Lollards. But in Bohemia his disciple, John Hus (1369–1415), created the tradition of 'protestantism' which led to the 16th-century Reformation.

A page from Wycliffe's English translation of the Bible

1067.—Specimen from a Copy of Wycliffe's Bible, in the British Museum. (Royal MS. I. C. viii.)

CHINA – plateau

CHINA, with an area of about 4,300,000 square miles, is, after Russia and Canada, the largest country in the world. Its landscape is immensely varied. It ranges from the snow-clad mountains and windswept plateau of Tibet to the flat, fertile delta of the Yangtze Kiang; and from the dry, barren Gobi Desert to the tropical rain-forest of the south coast. Much of the country is too rugged or too dry for cultivation, and so most of the population (700,000,000–800,000,000, the largest in the world) is concentrated in the south-east.

A HIGH COUNTRY

China is dominated by mountains, for more than half the country lies at a height of over 3,000 feet. From a central core in Tibet, the 'roof of the world', mountain ranges stretch out towards the Pacific Ocean, forming rugged barriers between the flood plains of China's great rivers.

VAST MOUNTAIN RANGES

China's southern and western frontiers are formed of some of the highest chains of mountains in the world: the Himalayas, which include the 29,002-feet-high Mount Everest; the Karakoram range; and the Tien Shan or 'Celestial Mountains'. To the north of the Himalayas is the great lake-studded plateau of Tibet. A cold, barren, windswept waste, mostly over 12,000 feet above sea-level, it is unpeopled but for a few nomadic tribesmen and their herds of scrawny yaks, goats, and sheep. But it is here that most of the great rivers of south-east Asia have their sources.

Minya Konkar (24,900 feet), one of the rugged, snow-covered peaks of eastern Tibet

THE TARIM BASIN. South of the Tien Shan mountains is the Tarim Basin, a vast desert of bare sand dunes, continually shrouded in a dust haze. On the margins of the desert is a series of oases, where cereals, cotton, and fruit are grown in terraced, irrigated fields. The water is supplied by mountain streams, which eventually flow into the desert to disappear into the 'sea of sand'.

THE GOBI DESERT. The Gobi Desert differs from the Tarim Basin in that its floor is mostly of rock, with only a thin veneer of sand and pebbles. It supports parched, wiry grass and some thin scrub – the only pasture of the camels, horses, and sheep of the nomadic Mongols who roam the desert. Both people and animals are extremely hardy, for they have to survive the almost tropical heat of summer, the Arctic temperatures of the eight-month winter, and the frequent buffeting of gale-force winds.

THE LOESS LANDS. Wind-blown material from the Gobi Desert has covered much of the plateau country of Shansi, Shensi, and Kansu. Often these loess deposits are thousands of feet thick, and, because of their softness, rivers have cut deep ravines into them. The roads, too, have sunk below the general surface level, and their steep walls have been hollowed out to provide houses that are cool in summer and warm in winter. Above, the flat or gently rolling surface is split into small fields of cereals, cotton, tobacco, and ground-nuts. In Shansi and Shensi are found China's main coalfields.

A lonely traveller treks across the Gobi Desert with his camel

THE NORTH CHINA PLAIN AND MANCHURIA. The North China Plain is largely formed of alluvium laid down by the Hwang Ho river. The monotony of the flat, featureless landscape is increased by the drab, brownish-yellow colour of the dry, dusty soil. Bankless rivers, choked with yellow silt, wander aimlessly among tiny fields of millet, wheat, and oil reeds. Manchuria, to the north-east, consists of a well-cultivated central plain surrounded by high mountains.

A scene on the Yangtze Kiang near Chungking; note how the jagged rocks endanger navigation

GREAT RIVERS

Rivers are the life-blood of China. Their significance as a means of communication is shown by the number of great cities sited on them: for example, Nanking, Wuhan, and Canton. But more important are their fertile alluvial plains which support an extremely dense rural population. The Hwang Ho (also called the Yellow River because of its muddy colour) rises in Tibet, and, after cutting a deep gorge through the loess country, emerges on to the North China Plain. Because of silting, it flows above the level of the fields, which are protected by mud-banks. The river has often changed course, causing severe floods and loss of life; from 1938 to 1947, for instance, it entered the sea south of the Shantung peninsula. Although it supplies rich alluvial soil, it is better known for the disasters it has caused, being well named 'China's Sorrow'. The Yangtze Kiang, which is 3,430 miles long, also rises in Tibet; it then flows through a series of fertile basins, entering the sea at Shanghai. Its delta, a vast alluvial tract criss-crossed with canals, is known as 'the Holland of China', and is the country's chief centre for silk production. The valley of the Si Kiang is smaller than those of the Hwang Ho and Yangtze Kiang, but rice and tea flourish in its tropical monsoon climate.

The loess country, showing the fertile but deeply scored farmland

THE RED BASIN

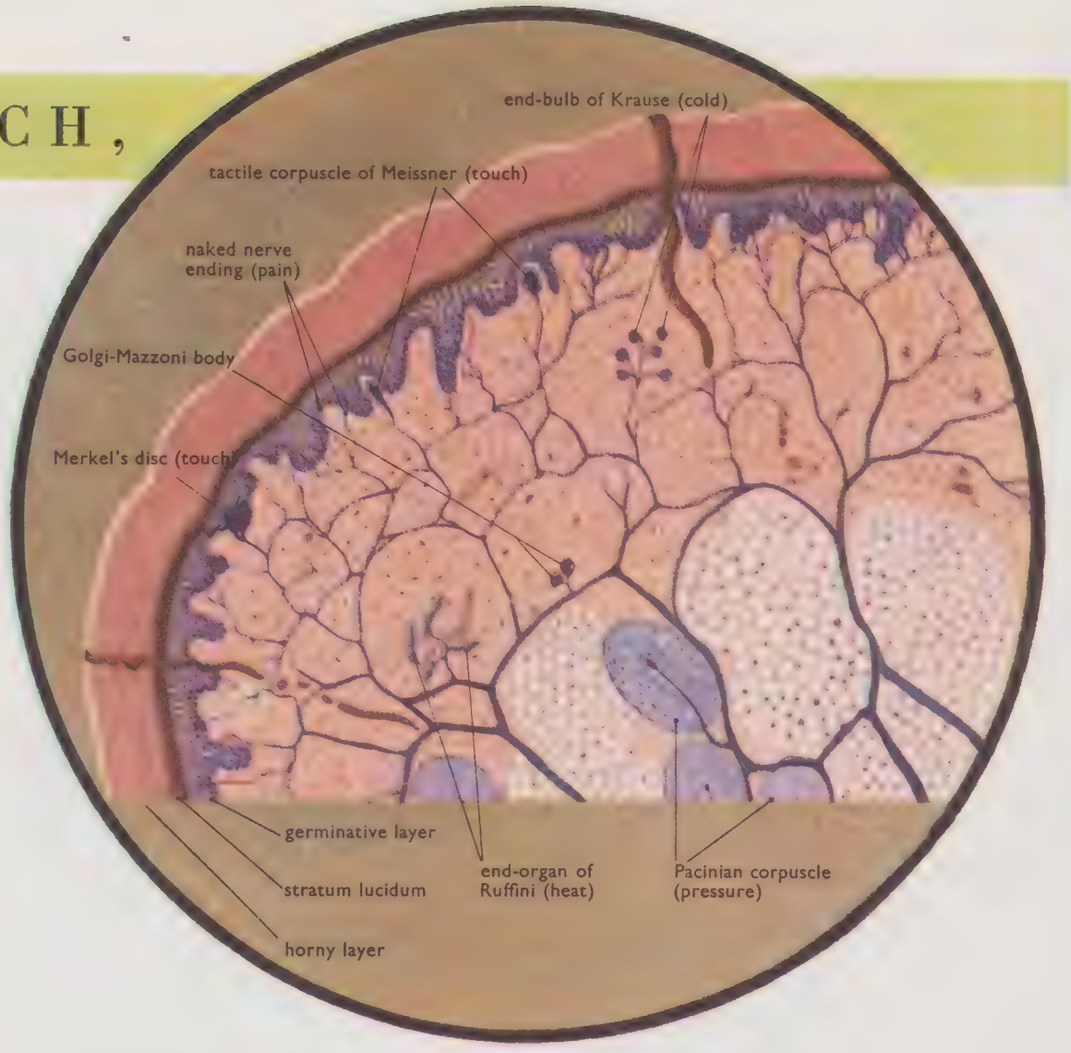
The Red Basin, which is centred on Chungking and Chengtu, is a remarkable area, completely hemmed in by mountains. For centuries it was isolated from the rest of China. Even today it is difficult to reach, and much of its traffic has to brave the rapids of the Yangtze gorges. The Basin is formed mainly of red sandstones, which have been deeply eroded to produce rounded hills and steep-sided ravines. But, in spite of its rugged nature, it is intensively farmed and covered with terraced fields. Its short, mild winters allow continuous cultivation, and, in some years, five or six crops are harvested.

PAIN, TOUCH,

THE sting of a bee, the prick of a pin, the sear of a burn: few sensations are less welcome than these, and yet, in its way, each is a useful and valuable experience. Each is a signal that a part of the body has been injured, and each accompanies the automatic reflex action which frequently withdraws the injured part from the cause of harm.

Pain is the most noticeable of the sensations which originate in the skin. The sensations of touch, of heat and cold, and of pressure are far less insistent. Together, however, they form an unceasing commentary on the body's surroundings which is transmitted along nerves to the brain, where it becomes part of conscious experience.

Pain, besides originating in the skin, may also arise from deeper tissues such as muscles, bones, and the organs within the chest and abdomen. Such pain is almost invariably an indication of injury or disease within the tissue. Again it is a warning that part of the body is in need of attention, and the quality of the pain experienced is often characteristic of the organ that is affected.



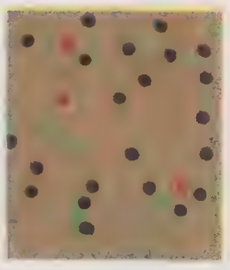
This diagrammatic section through a portion of skin and subcutaneous tissue shows the disposition of the various types of cutaneous receptor organs

This diagram shows the number of spots sensitive to pain, to heat and cold, and to pressure in various parts of the body. Great patience and the help of a very co-operative person are needed to obtain information of this kind. The work is very tedious and involves the examination of small areas of skin in different parts of the body for spots sensitive to each kind of stimulus. The 'map' which is prepared when the tests are complete shows the number and the distribution of all the sensitive spots in each tested area

The sensitivity of the skin

Strangely enough, the ability of the skin to sense painful stimuli, such as the prick of a pin, is not continuous over the whole of its surface. This can be demonstrated quite easily. First draw a thin line about a quarter of an inch long on the skin of one forearm. Next press the point of a sharp, clean needle lightly into the skin, just to one side of the lower end of this line, and make a mental note of the intensity of the pain that you experience. Then move the needle point a minute distance along the line, and again press it lightly into the skin and make a note of the intensity of the pain. After you have done this only about six times you will see quite clearly that much of the skin surface is relatively insensitive to pin pricks. The sensitive areas – and these are indeed very sensitive – are quite small, and there are not many of them.

By means of a technique like that used with the needle, but using instead a little bristle, it is possible to show that the sensation of touch is also limited to certain spots on the skin surface, and small, warmed and cooled metal rods will demonstrate the same phenomenon for heat and cold. The results of the examination of a small square of skin for spots sensitive to the various stimuli can be used to make a skin 'map' showing the distribution of the sensitive spots and demonstrating that they are independent of each other.



This enlarged 'map' shows the distribution of touch (black), cold (green), and heat (red) spots on the back of the hand

AND THE SENSATION OF TEMPERATURE

THE RECEPTOR ORGANS

The sensitivity of the skin to different kinds of stimuli is due to the presence of *cutaneous receptor organs*. At least seven different types can be recognised, and each type is thought to be sensitive to one kind of stimulus only.

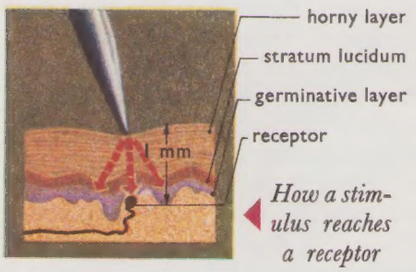
Touch. Two types of receptor organ, the *tactile corpuscles of Meissner* and the *discs of Merkel*, are concerned with the sensation of touch. Both lie near the surface, just beneath the germinative layer of the epidermis.

Cold. This sensation is thought to be due to stimulation of the cold receptor organs, known as the *end-bulbs of Krause*. These organs are spherical or near spherical, and there are many of them on the lips and on the tongue.

Heat. The organs responsible for the reception of heat stimuli are thought to be the structures called after the Italian anatomist, Ruffini, who discovered them. These structures lie deep in the dermis.

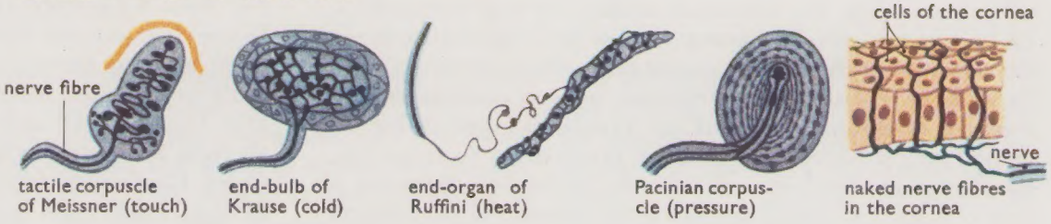
Pressure. A particularly large receptor called a *Pacinian corpuscle* is responsible for the reception of the sensation of pressure: much smaller pressure receptors known as *Golgi-Mazzoni corpuscles* are found nearer the surface.

Pain. At one time the sensation of pain was thought to result from overstimulation of any of the receptors but it is now thought that the sensation of pain results from the stimulation of the naked nerve fibres which spread through the tissues.



How a stimulus reaches a receptor

DIFFERENT KINDS OF RECEPTORS



tactile corpuscle of Meissner (touch) | end-bulb of Krause (cold) | end-organ of Ruffini (heat) | Pacinian corpuscle (pressure) | naked nerve fibres in the cornea

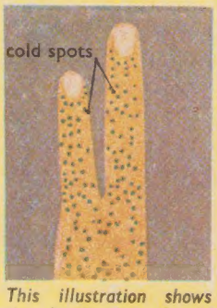
THE SENSATION OF TOUCH

The sensation of touch is particularly important as it provides a great deal of information about the body's environment. The contact of any object with the surface of the body is immediately apparent, and if this contact is recognised as a damaging one action can be taken to avoid it.

A continuous touch stimulus soon fails to call forth a conscious sensation. Although clothes are in constant contact with the surface of the body, and are doubtless stimulating the corpuscles of Meissner, we do not recognise their presence if they fit properly. The sensation of touch, in association with the sensation of pressure, provides the faculty of *stereognosis* – the ability to recognise objects held in the hand but not seen. Many of us have played a game testing this ability, in which objects are passed round in the dark and we have to identify as many as possible.

THE SENSATION OF TEMPERATURE

The spots on the skin sensitive to cold outnumber the spots sensitive to warmth by about four to one. They are, however, quite sparse on those parts of the body which, like the hands and the face, are normally exposed to the air. An interesting feature of the sense of temperature is the rapidity with which it becomes 'adapted'. Put your left hand in a bowl of cold water and your right hand in a bowl of hot water. Leave them there for a minute or two. Now put them both in a bowl of tepid water. The left hand will sense the tepid water as warm, while the right hand will sense it as cold.



This illustration shows the distribution of cold spots on two fingers

THE SENSATION OF PAIN

The sensations of touch, of pressure, and of heat and cold serve to provide the body with information about its environment. They are seldom unpleasant. The sensation of pain is quite different, for it is generally a warning that a part of the body is in danger.

Three quite different kinds of pain are recognised. They are:

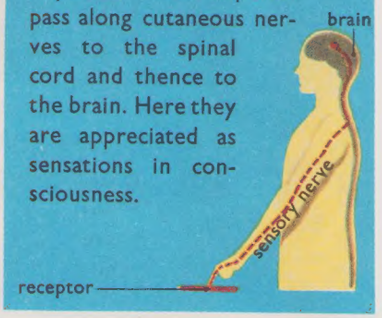
(1) *cutaneous pain*, which originates in the skin as a result of some form of superficial injury;

(2) *deep pain*, like that experienced during an attack of cramp or when a bone is broken, which originates in the deep tissues;

(3) *visceral pain*, which arises in the internal organs when their function is upset by disease.

THE PATHWAY OF SENSATION TO THE BRAIN

When a receptor is stimulated by the particular stimulus to which it responds it discharges nerve impulses. These impulses pass along cutaneous nerves to the spinal cord and thence to the brain. Here they are appreciated as sensations in consciousness.



The route of the sensory impulses discharged by a receptor

JAMES I (1603-1625)

SOME kings are important because they were successful. James's reign was important because he was unsuccessful, for his quarrels with Parliament were of vital importance in the development of the English constitution. Throughout his reign Parliament criticised his religious policy, condemned his methods of taxation, scorned his 'favourites', and defied his foreign policy. There was not much James could do about this, for Parliament held the whip hand. James had inherited a debt of £400,000 from Elizabeth I, the expenses of government were increasing, and only Parliament, which granted taxes, could relieve his financial plight.

There was trouble with the first Parliamentary session of the reign. The Commons at once decided to assert the privileges they had claimed in the previous reign. They overruled a decision of the High Court which refused permission for Sir Francis Goodwin, an outlaw, to take his place in Parliament, so denying the King's power to interfere with elections. They succeeded in getting Sir Thomas Shirley, an M P, released from a debtors' prison, thus vindicating the principle of freedom from arrest for M Ps. As well, they drew up an 'Apology' of their 'ancient privileges'. Indeed the unfortunate James was so harassed by Parliament that when he prorogued (temporarily suspended) it in 1604 he made a sarcastic reference to 'my masters of the lower house'.

However, the following year brought the Gunpowder Plot (see page 1034), a Roman Catholic conspiracy to blow up the King and both Houses of Parliament. This failed, and Parliament, relieved at its escape, was much more friendly and granted the King the taxes he required.

Nevertheless, James still had not enough money. From 'ordinary' taxation granted in Parliament he turned to 'extraordinary' methods of raising money. These included exploiting 'feudal' rights like wardship and purveyance, levying duties like tonnage and poundage, and raising loans, unrealistically called benevolences. His position was strengthened by Bate's case (1606). John Bate refused to pay his poundage and was condemned by High Court judges. In 1608 a new Book of Rates, increasing such taxes, was produced by the Treasury. The Commons were furious. They refused more taxes and complained bitterly of the King's methods. Negotiations for a Great Contract, by which the King should surrender feudal rights, like wardship, in return for grants to pay off his debts, broke down. In 1611, exasperated by criticisms of his personal conduct, James dissolved his first Parliament.

James's troubles were partly due to circumstances and partly his own fault. Since he came from Puritan Scotland (where he had been King since 1567 as James VI) the Puritans in the House of Commons expected much from him. Yet in an age when so many thought 'no bishop' meant 'no king', no king could be a Puritan. Moreover, James I had exalted notions of his own 'Divine Right', and constantly lectured Parliament on how all right and goodness flowed from the King. At the Hampton Court Conference (1604) he told the Puritans that if they did not conform to the Established Church they would be driven out of the land. James also made the error of sending his ablest men (including his Privy Councillors) from the Commons to the Lords; and he showed undue favouritism to men like the Earl of Somerset and the Duke of Buckingham, whose only merit, in the nation's eyes, was their good looks.

In 1614 James summoned what was designed to be a 'Parliament of Love', but it immediately criticised the benevolences which the King had collected, and then attacked Buckingham. The King at once dissolved this Parliament, which is known to history as the Addled Parliament.

Foreign policy

In 1618 the Thirty Years War broke out between Catholics and Protestants in Germany. In 1620 James's son-in-law, Frederick, Elector of the Palatinate, was decisively defeated and fled into exile. This put James in a dilemma, for he naturally wanted to help restore his son-in-law to the Palatinate. Moreover, as this would have helped the Protestant side in the war, it would have been popular with Parliament. But James had long been working for the marriage of his son, Charles, with the King of Spain's daughter. Spain was still considered the strongest nation in Europe. It was also a Roman Catholic country. Despite the latter, James thought that if his Spanish alliance materialised, Spain would back out of the war and withdraw aid from the Roman Catholics. In 1621 he summoned Parliament and asked for £900,000 to help restore Frederick. But Parliament insisted that war should be declared on Spain. It challenged the King's abuse of 'monopolies', criticised Buckingham, and attacked the projected Spanish marriage. The King dissolved Parliament in a temper. He ordered the arrest of the leader of the opposition, Sir Edward Coke, the great lawyer, and also ordered the confinement of John Pym, 'the Uncrowned King of the Commons'.

In defiance of Parliament, Prince Charles and Buckingham went disguised to Spain in 1623 to woo the Spanish princess. They only succeeded in driving her into a convent, and returned, in October 1623, as furious with Spain as Parliament had been. From now on, King and Parliament were agreed as far as foreign policy was concerned. James actually invited his next Parliament to advise him on foreign policy, and in June 1624 signed an offensive treaty with the Dutch. The same year the King agreed to the important Statute of Monopolies which restricted his use of monopolies. This surprisingly amicable atmosphere lasted until James died in March 1625. Yet beneath the surface smouldered serious constitutional disagreements between the democratically minded Parliament and the monarchy, convinced of its 'Divine Right' to rule. These were to explode into violence and tragedy in the succeeding reign.

James I and his son Charles feast the Spanish Ambassador, Gondomar; it was a feast wasted, for the prospective Spanish marriage came to nothing

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their problems by use of what is now known as Pythagoras's theorem (see **Geometry**).

Because both Egypt and Greece lie on the Mediterranean Sea, and were great seafaring and trading nations, there were periodic meetings between the mathematicians and philosophers of Greece and the engineers of Egypt. The Egyptians could work out the area of a rectangular field, but the Greeks went further. They set about applying geometry not only to lines and rectangles but also to circles and triangles. They introduced such terms as 'radius' and 'angle'. The Greeks endeavoured to find a common formula to link areas of all regular symmetrical figures such as the square and the circle. In this they came up against one of the most tantalising and insoluble problems in mathematics – 'squaring the circle'. This means drawing, with only ruler and compasses, a square equal in area to a given circle or vice versa. Today we know that the ratio of the area of a circle to the area of a square, the side of which equals the radius of the circle, is 3·14159.... The Greeks called this figure π, and the Greek Archimedes said that π was between $3\frac{1}{7}$ and $3\frac{10}{71}$. But no one has ever been able to calculate π exactly, nor will they ever. π just goes on *ad infinitum*. Here is π worked out to 50 decimal places: 3·14159265358979 32384626433832795028841971693993751O. Even if you had a number which stretched round the world, you would still not have its exact value.

Before the Greeks, the Jews and Babylonians had come up against the problem of π. They thought it was 3, as shown in the Bible: 'And he made a molten sea, ten cubits from the one brim to the other; it was round all about, and his height was five cubits; and a line of 30 cubits did compass it round about' (1 Kings, chapter 7, verse 23). This implies that the ratio of the circumference to the diameter of the cylinder (also π) was 30 divided by 10, or 3. The Egyptians came closer with their approximation of $\frac{256}{81}$ or 3·1605.

Until the 16th century approximations to π were made by constructing regular polygons with a large number of sides both inside and outside a circle, and taking the average of the area of each polygon to be equal to the area of the circle. Various other approximations were used for π from time to time, namely $3\frac{1}{7}$, $3\frac{10}{71}$, $\frac{355}{113}$, $\frac{377}{120}$. It was not until the 17th century that the presently held value of π was arrived at.

The number π has many remarkable properties. For example, if one draws a number of parallel lines on a plane, each the same distance from the one before, and then throws a pin, of length half this distance, quite at random on to the plane, the chance of the pin lying across one of the lines is $\frac{1}{\pi}$. Another extraordinary thing is that $\frac{\pi}{2}=\frac{2.2.4.4.6.6.8.}{1.3.3.5.5.7.7.}$ and so on.

A Babylonian making a calculation, and (right) a clay tablet with Babylonian numerals

The development of algebra

The word *algebra* (the substitution of letters for numbers) was probably first used by Mohammed ibn Musa al-Khowarizmi in about A D 825 when he published, in Baghdad, *Al-jebr w'al-muzabalah*, which is roughly translated as 'Restoration and Equation'. But the algebraic method was probably introduced by a Greek, Diophantus, practising in Alexandria during the 2nd century A D. The use of symbols for numbers helps mathematicians to calculate unknown quantities, or produce answers in terms of these quantities. Moreover, several problems can be reduced to a single one.

Decline in mathematics

From the 3rd century A D a decline in intellectual pursuits set in as the centre of world power moved westwards to Rome. Even at the height of Roman majesty, when the vast empire stretched right across Europe, the achievements in mathematics and science were little more than trivial, whereas the contributions in the fields of law, literature, and art were exceedingly great. So the 3rd to 13th centuries yielded little to the advancement of mathematical knowledge.

Not until after 1453, after the fall of Constantinople to the Turks and the collapse of the Byzantine empire, did advances in mathematics really take place. The scholars and professors of Constantinople, a city then generally acknowledged as the centre of learning, fled to Italy and Germany, the two most prosperous countries at that time. In Italy algebra developed; from Germany came advances in trigonometry and astronomy.

The Renaissance and after

The 16th-century mathematicians in Europe helped to clear up some of the unsolved problems carried over from the Greek mathematicians. One of these problems had been the solution of certain types of equations. An equation is an algebraic statement of equality – for example, $x+2=3$. An equation in 'x' is called *cubic* when the highest power

Two strange-looking systems of numerals: above, Chinese; below, Babylonian

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GREAT MEN ON MATHEMATICS

Euclid: There is no 'royal road' to geometry.

Galileo: In questions of science the authority of a thousand is not worth the humble reasoning of a single individual.

Izaak Walton: Angling may be said to be so like the mathematics, that it can never be fully learned.

Sidney Smith: What would be life without arithmetic but a scene of horrors?

of x is 3 (x^3); *quadratic* when the highest power of x is 2 (x^2); and *linear* when the equation is of a type, $x+2=3$. The equation is, and was, particularly important for finding out more about an unknown quantity. In 1455 the Italian Girolamo Cardano, professor of mathematics at Venice, produced a new method of solving all cubic equations. He was able to reduce every cubic equation to an equivalent equation for which he propounded a general solution. This discovery gave great stimulus to the theory of equations all round Europe.

Britain came to the fore in mathematics in the 17th century, when two of her leading mathematicians, Napier and Newton, propounded and proved theorems that stand as the basis of modern mathematics. John Napier (1550–1617), born near Edinburgh, invented *logarithms* – the expression of one number as a power of another (often 10). Thus $\log_{10}$ of $100=2$ ($100=10^2$). The result of this is an extremely easy way of multiplying and dividing. To multiply two numbers their logarithms are added; and to divide, their logarithms are subtracted.

In the same century lived Sir Isaac Newton (1642–1727), who is justly regarded as the father of modern mathematics. His working life was mostly spent at Trinity College, Cambridge, and he was President of the Royal Society. His interest and discoveries in mathematics were far-reaching, and were not restricted to any one particular branch of the subject. Newton's major advances in mechanics, for example, were mainly extensions of the work done by the Italian mathematician Galileo (1564–1642) who undertook practical experiments in mechanics. Galileo established, by considering bodies in motion, experimental relationships between mass, distance, and time. From these, Newton developed his famous laws of motion.

Another of Newton's achievements was the discovery of *differential calculus*. The German mathematician, Leibnitz (1646–1716), working independently, developed the theory of *integral calculus*, the converse of differential calculus. It is an extraordinary fact that differentiation and integration, discovered so independently, are linked at all stages of their development. Calculus is a method of calculation where there are variables involved, unlike arithmetic which is concerned only with constants. For instance, when a rocket is launched it burns up fuel at a constant rate. But as the fuel is burned up the rocket becomes lighter, and its acceleration therefore increases. If we want to know the final velocity of the rocket we must resort to calculus. The methods involved are difficult for people with only an elementary knowledge of mathematics to understand, but they form an essential part of mathematics today.

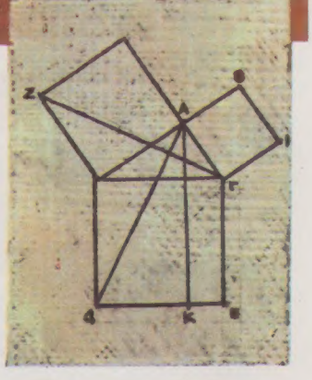
In 1687 Newton published his major work, *Philosophiae Naturalis Principia Mathematica*, summarising his work to date, and also giving details of his fine work on gravitation theory. He had discovered the law of gravitation – namely, that mutual action exists between masses of matter such that each mass is attracted towards every other mass with a force proportional as the product of the masses and inversely as the square of the distance between them. His work on gravitation proved the theories that the German Kepler (1571–1630) had propounded with reference to the laws of motion of the planets.

Thus astronomy now opened up as a mathematical science. The telescope had been invented in 1608, and this had led to Galileo discovering sunspots, four of the satellites of Jupiter, and the phase of Venus. Most research in this field was undertaken by the Germans.

During the 17th and 18th centuries mathematics was developed mainly by people working in universities or under the patronage of royal households. Most of the original work of this time was in the fields of algebra and analysis, and was carried out in France and Prussia by such men as Euler (1707–1783), d'Alembert (1718–1783), Lagrange (1736–1813), and Laplace (1749–1827). These men not only developed their own subjects but helped to fill in some of the gaps in the knowledge of other fields of mathematics and science – and indeed this interchange of ideas between scientists has been an essential part of the development of scientific knowledge since the earliest times.

In the 19th and 20th centuries enormous advances have been made in mathematics, and its application to our everyday lives. In our next article we will see how these came about, and look more closely at the different branches of mathematics.

Euclid (c. 300 B C), the great Greek mathematician, studies the famous theorem of Pythagoras (right) on whose work he based much of his own



'The square on the hypotenuse is equal to the sum of the squares on the other two sides'